The Diet of the Pilliga Mouse, *Pseudomys pilligaensis* (Rodentia: Muridae) from the Pilliga Scrub, Northern New South Wales

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The contents of the digestive tracts from five Pilliga mice (*Pseudomys pilligaensis*), collected over twelve years, were processed. Seed was the most abundant food in the diet and was represented by five or six seed types in Spring/Summer and accounted for 95% of the diet, with leaf contributing less than 2%. InWinter, seed contributed 62% of diet, represented by more than twelve seed types with leaf contributing 38% of the diet. These results indicate that *P. pilligaensis* is a specialised granivore, although it may be more opportunistic in winter.

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KEYWORDS: diet, granivore, Pilliga mouse, *Pseudomys pilligaensis*.

INTRODUCTION

The Pilliga mouse, *Pseudomys pilligaensis* (Rodentia: Muridae) was first captured in 1975 and was thought then to be an unusually small specimen of the New Holland Mouse (*Pseudomys novaehollandiae).* However, material collected over the following years revealed significant morphological differences between the animals from the Pilliga and other Conilurine rodents and a new species was described by Fox and Briscoe (1980). Briscoe, et al (1981) used electrophoretic analysis to clearly demonstrate genetic differentiation between *Pseudomys pilligaensis* and related *Pseudomys* species.

Very little is known about the Pilliga mouse except that it is terrestrial and appears to live in burrows, often in sandy substrate. It apparently has an extremely restricted distribution, and is known only from the Pilliga Scrub including Pilliga State Forests. This area is situated north of Coonabarabran in northern New South Wales. It is a forest on an isolate sand substrate, supporting a mixed Callitris-Cypress-Pine-Eucalyptus forest and heath communities (Fox and Briscoe 1980). All known individuals captured up until 1988 appear to have been within a 50 km radius. The status of the Pilliga mouse has been listed as rare, limited, vulnerable and perhaps at risk but possibly under estimated (Strahan 1995). The Pilliga mouse is nocturnal and inhabits areas with sparse ground cover. The Pilliga mouse is similar in appearance to the New Holland Mouse, *Pseudomys novaehollandiae* which has a coastal distribution and is restricted to sandy areas. Both are nocturnal and inhabit areas with sparse ground cover.

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In captivity, animals live in family groups. The breeding season (in captivity) extends at least from October to mid-February and the gestation period is between 24 and 31 days. Young are born with the incisors erupted and eight laboratory-born litters had a modal size of three young (Fox and Briscoe 1980).

There are no published data on the diet of this species. This study examined the diet of five wild-caught individuals of *Pseudomys pilligaensis*, using microscopic analysis of faecal samples which were collected over a twelve year period. Any knowledge of the natural diet and cues for habitat selection are crucial in understanding the biology of any rare native rodent (Cockburn 1981a,b). This information could substantially contribute to the understanding of its habitat requirements and to the conservation management of this rare and endangered species.

STUDY SITES

The five individuals were all captured from localities within the Pilliga Scrub area (Table 1). The specimens came from habitats in mixed cypress-eucalypt forest and woodland. The dominant canopy species were red stringy bark (*Eucalyptus macroryncha*), scribbly gum (*Eucalyptus rossii*) and black cypress pine (*Callitris endlicheri*) with Blakely's red gum (*Eucalyptus blakelyi*) and rough barked apple (*Angophora floribunda*) in creek lines, which also had stands of bottle brush (*Callistemon*) and tea tree (*Leptospermum*) in the understorey. Apart from creek lines the sparse understorey comprised heath-type shrubs similar to the She-Oak (*Casuarina distyla*) dominated heath adjacent to the forest. More detailed descriptions of the vegetation and a plant species list are provided by Fox and Briscoe (1980). The Pilliga State Forests have a very unpredictable physical environment with annual rainfall around 625mm with a summer maximum. Variation in annual rainfall is great, with periods of both great drought and extreme wet being common (Norris et al.1991; Hart 1995).

METHODS

The digestive tracts of five spirit specimens of *Pseudomys pilligaensis* were carefully removed from the body cavity and opened using fine scissors and fine jewellers forceps. Three of the specimens contained faecel pellets only (BF. 791103; BF. 791105 and NPWS 1-88) while the remaining two specimens contained material in all sections of the digestive tract (A.M. M10438; and A.M. M10602) (see Table 1,specimens No. 1, 3 and 4 , described by Fox and Briscoe 1980). Hence to be consistent, only the faecal pellet data were used in comparing the diets.

The contents of each section of the tract were flushed with 75% alcohol and placed into separate containers and categories (i.e. caecum, stomach, large intestine). Faecal pellets when present were carefully removed from the rectum. Thus one sample consists of five faecal pellets that were randomly selected from one mouse. Each sample was washed through a column of five different sieves with 0.58, 0.41, 0.26, 0.15, and 0.13mm mesh. Any material passing through the smallest sieve was collected on filter paper was divided into six sub samples. Each subsample was transferred into a labelled test tube to allow materials to be homogeneously mixed. The material was then transferred from each tube with a pipette to a correspondingly labelled slide (25.4 x 76.2mm) which was placed on a hotplate at 30C to dry. After all moisture on the slides was evaporated the slides were removed from the hotplate, placed on a flat surface and slowly covered with modified Berlese mounting medium (Luo 1993). The completed slides were then left

Table 1. Localities of *Pseudomys pilligaensis* and Collection Data

Specimen No. / Catalogue No.	Location – (Lat., Long.)	Date collected	Season	Collector
1. AM. M10438	Timmallallie Creek (31° 51'S, 149° 28'E)	14 July 1976	Winter	A.Rose
2. AM.M10602	Pilliga E. State Forest (30° 31'S, 149° 16'E)	July 1977	Winter	F.Shlager
3. BF. 791103	Timmallallie Creek (31° 51'S, 149° 28'E)	Nov.1979	Spring	B.J.Fox
4. BF. 791105	Timmallallie Creek (31° 51'S, 149° 28'E)	Nov.1979	Spring	B.J.Fox
5. NPWS. 1-88	Pilliga Nature Reserve (31° 51' S, 149° 28'E)	19 Sept.1988	Spring	L.Lim

Catalogue Numbers: AM = Australian Museum, BF = Barry Fox, NPWS = National Parks and Wildlife Service

undisturbed for 2-3 days until the mountant set hard. This modified medium not only clears the material but also has an ability to preserve and retain the original appearance of the faecal pellet material, whether that be fresh green material or old yellow mature plant material. The amount of material on each slide was standardised using a scoring (frequency-of-occurrence) technique as described by Johnson 1982; Luo 1993; Fox, Read, Jefferys and Luo 1994 .

Estimation of Dietary Composition

Generally the food material in the samples of *P. pilligaensis* could not be identified to species and was classified as leaf, stem, seed, insect, pollen, sand granules or unidentified (following the protocol of Fox, Read, Jefferys and Luo 1994). As rodents tend to masticate their food very finely, positive identification of food items (e.g. epidermal tissue) is extremely difficult. Some small pieces of plant material could be identified to genus by comparison with the plant slide collection in the ecology laboratory at the University of New South Wales.

All six slides from each sample were scored because different dietary items were best represented on slides with the appropriate sized particles. A total of 50 fields of view at 40 x magnification were scored for each of the six slides from each sample. The frequency of occurrence of each food category was recorded from its presence or absence in each field. Next the number of scores or frequency for each food item was summed over all slides and the percentage of each category in the diet, from 300 fields of view, was calculated as

$$P_i = (f_i/\Sigma f_i) \times 100\%$$

where P_i is the percentage and f_i the frequency of i^{th} food item.

Although some authors have calculated frequency percentages as the number of fields in which a food category occurred out of 100 fields, then converted them into relative percentage of occurrence (e.g. Sparkes and Malechek 1968; Cockburn 1980; Carron , Happold and Bubela. 1990), the above equation determines the relative percentage of occurrence of each food item irrespective of the number of fields scored. Detailed discussion of the techniques we have used are presented in Luo 1993; Fox, Read, Jefferys and Luo 1994; Luo , Fox and Jefferys 1994.

RESULTS

Table 2 shows the percentage dietary composition of the five faecal samples of the Pilliga mice collected in the wild. Overall plant material (stem, seed, and leaf) was the most abundant food in the diet of *P.pilliagensis,* accounting for more than 94% of its total diet. There was no pollen present in any of the samples. The bulk of the plant material was seed, over 80%, and 22 seed types were recognised, 12 of which were monocots and 10 seed types recognized as dicots. Table 3 shows seed types found in the diet of *Pseudomys pilligaensis*. The seed types 16 to 22 ocurred only at trace levels. The seeds were finely masticated but some particles were large enough to make some general identifications. The Monocot seed material appears to come from the genera of *Cyperus*, *Lepidosperma* and *Schoenus*, (Cyperaceae); *Poa*, *Juncus, Aristida, Cymbopogon, Dichelachne , Digitaria, Entolasia, Eragrostis, Imperata,* and *Triodia* spp. (Poaceae) all of which are found in the Pilliga Scrub area.

Leaf material found in the diet varied from 1% in spring to 52% in winter. Stem material varied from 4% in spring to 1% in winter Sample No. 3 (BF. 791103) contained small traces of leaf of the plant species *Aotus subglauca*, family Fabaceae. Most of the

Table 2. Percentage composition of diet items in the faeces of five *P. pilligaensis* individuals. Sand was present in all samples.

Specimen No.	1	2	3	4	5
SEED TYPES	1–3,5,6,8-10,12,17-19 = 12 seed types	1–6,8-11,14,18,21 = 13 seed types	1,3,11,13,15,16 = 6 seed types.	3,7,21,22 = 4 seed types	5,19, 20, = 3 seed types
SEED	47	76	99	95	91
STEM	1	0	1	1	2
LEAF	52	24	0	4	1
INSECT	trace only	2	trace only	trace only	6
SEASON	winter	winter	spring	spring	spring

Table 3. Seed types found in the diet of *Pseudomys pilligaensis*

Seed Type	Class	Family	Genus/species
1	Monocotyledon	Poaceae	
2	Monocotyledon	Poaceae	Digitaria sp.
3	Monocotyledon	Poaceae	Poa sp.
4	Monocotyledon	Poaceae	Stipa sp.
5	Monocotyledon		grass type
6	Monocotyledon		grass type
7	Monocotyledon		grass type
8	Monocotyledon		grass type
9	Monocotyledon		grass type
10	Monocotyledon	Cyperaceae	Cyperus sp.
11	Monocotyledon	Cyperaceae	Cyperus sp.
12	Monocotyledon	Juncaceae	Juncus sp.
13	Dicotyledon	Goodeniaceae	Goodenia sp.
14	Dicotyledon	unknown family	
15	Dicotyledon	unknown family	
16	Dicotyledon	Portulaceae	
17	Dicotyledon	Myrtaceae	Angophora sp.
18	Dicotyledon	Solanaceae	Solanum sp.
19	Dicotyledon	Malavaceae	
20	Dicotyledon	unknown	
21	Dicotyledon	unknown	
22	Dicotyledon	unknown	

leaf material was Monocot and was associated with the seed eaten (i.e. glumes and lemma). All of the leaf material in sample No. 1 AM.M10438 was Monocot material and is either Poaceae or Cypeaceae family. Some of the leaf cells were identified as belonging to the family Poaceae (grasses) by the dumb-bell shaped silica bodies in the cells. Dicot leaf was observed.

Fungal spores were present in one individual (No. 4 BF. 791105) but as only two single spores were present it would appear that this was accidentally ingested and does not appear to be part of their diet. Dirt and sand granules were present in all samples but in insignificant proportions. However as there is no evidence of any root material or any soil invertebrates, this suggests that the mice were probably not digging to acquire any of the food in their diet at these times.

Insect material was found in all five individuals but only four of the samples were able to be identified. Larval skin from the same species of Lepidopteran caterpillar was found in both diets from spring (BF. 791103 and BF. 791105) winter (AM. M. 10602). Hymenopteran material identified as ant (Formicidae) alate wings was found in winter (AM. M. 10602) and spring (NPWS. 1-88), and a section of ant gaster (Formicidae) appears in spring (BF. 791103). A section of leg of Orthopteran (grasshopper type) was found in winter. (AM. M.10602) so they appear to be consuming similar material over this time period.

Pseudomys pilligaensis appears to have a strictly granivorous diet during the spring/summer months (September to November), consuming from 91% to 95% of its diet as seed. This seed material is mainly yellow to brown and appears to be mature dried seed from 4 to 6 species. One type of seed (No.6, a grass type) appears in four of the five samples, and it appears in the diet in the years 1976, 1977 and 1979. However in the winter months they broaden the diet to include a much greater range of seed types and a higher proportion of leaf material.

DISCUSSION

It should be noted that the sample size is very small and any results will only be a limited appraisal of what the individuals were eating at the time of the sampling. The five samples represent one juvenile and four adults and were collected over a number of years. Winter samples comprised one adult in July 1976 AM. M.10438 and one juvenile July 1977 AM. M.10602. What we have classified as the spring/summer samples comprised two adults collected in November 1979, i.e. BF. 791103 and BF. 791105 and one adult from September 1988. Hence it is only possible to compare the diet for spring/summer and winter in a very broad manner. The results from the other sections of the digestive tract were very similar to those from the faecal pellets. This was also found to be the case with *Pseudomys novaehollandiae* diet analysis by Thompson (1980), with stomach contents having a close similarity to faecal pellets.

Insects do not seem to be a very important part of the diet, as they only range from 0 to 6% of the total diet. Insects, especially ants and termites, are readily available in this habitat (Rolls 1981; Hart 1995) and would provide more calories per gram than seeds (Golley 1961, Reichman 1975, Redford and Dorea 1984). The insect material in all of the diets could possibly have been accidentally ingested as they all are associated with the parts of the plants that were consumed. However, it would appear that these rodents are deliberately selecting plant material instead of insects at these times of the years. A comparison of the diet of *Pseudomys pilligaensis* with those of other species of *Pseudomys* in both spring/summer and winter (Table 4) shows that *P. pilligaensis* like all other species demonstrated a drop in the percentage of seed from spring/summer to the winter diet, but the magnitude of the shift differs. *Pseudomys novaehollandiae* is almost entirely dependent on seed (97%) in summer but drops to 45% in winter, while *P. apodemoides* drops from 86% in summer to 55% in winter (Table 4). These changes contrast with the

Table 4, A comparison of diet items in the faeces of *P. pilligaensis* with those for five other species of *Pseudomys* in (A) Spring/summer and (B) winter. Values are the mean percentage occurence ±standard error. Sources: Cockburn (1980); [2]Thomson (1980); [3]Cockburn (1981a), [4]Cockburn (1981b); [5]Fox et al (1994); [6]Luo and Fox (1994).

A) Spring/Summer diet items

Species (n=samples)	Leaf	Stem	Seed	Fungi	Insect	Other	Total
Pseudomys pilligaensis (3)	1.7 ±1.2	1.3 ±0.3	95.0 ±2.3	0 ±0	2.0 ±2.0	0 ±0	100.0
Pseudomys [1] *novaehollandiae* (5)	1.5 ±0.9	–	96.9 ±1.5	0 ±0	0.6 ±0.6	0.6 ±0.6	100.0
Pseudomys [2] *novaehollandiae* (35)	4.9 [a] ±1.2	a	81.2 ±1.9	–	3.8 ±0.3	10.0 ±1.0	99.9
Pseudomy [3] *apodemoides* (15)	4.9 [a] ±1.2	a	85.8 ±0.7	0 ±0	1.0 ±0.2	1.0 ±0.4	100.1
Pseudomys[4] *fumeus* (23)	1.4	–	58.6	19.8	12.6	4.9	99.9
Pseudomys[5] *oralis* (29)	44.6 ±2.2	0.3 ±0.1	44.2 ±2.1	0.3 ±0.3	7.3 ±1.2	3.4	100.1
Pseudomys[6] *gracilicaudatus* (25)	4.6 ±1.9	31.1 ±3.7	34.2 ±3.9	22.7 ±2.7	3.0 ±0.7	4.3 ±1.4	99.9

a Leaf and stem conbined

B) Winter diet items

Species (n=samples)	Leaf	Stem	Seed	Fungi	Insect	Other	Total
Pseudomys pilligaensis (2)	38.0 ±14.0	1.25 ±0.5	61.5 ±14.5	0 ±0	1.0 ±1.0	0 ±0	100.0
Pseudomys[1] *novaehollandiae* (7)	18.9 ±0.9		44.6 ±8.9	3.3 ±3.3	17.0 ±14.0	15.7 ±5.6	100.0
Pseudomys[2] *novaehollandiae* (22)	11.5 [a] ±0.6	a	54.7 ±0.3	–	7.3 ±0.7	26.6 ±1.5	100.1
Pseudomys[3] *apodemoides* (15)	8.1 [a] ±2.6	a	55.3 ±1.4	10.4 ±0.6	11.2 ±1.1	15.0 ±1.8	100.0
Pseudomys[4] *fumeus* (23)	1.6	–	26.7	55.0	6.6	10.2	100.1
Pseudomys[5] *oralis* (29)	77.0 ±2.2	6.5 ±1.5	11.6 ±1.8	1.1 ±0.6	2.3 ±0.4	1.5 ±0.8	100.0
Pseudomys[6] *gracilicaudatus* (36)	12.2 ±1.5	29.1 ±1.7	31.1 ±1.8	22.8 ±1.9	1.3 ±0.6	3.4 ±0.9	99.9

a Leaf and stem combined

larger species, *P. oralis* which has seed as 44% of its diet in summer and 12% in winter, the lowest use of seed in winter, but consumes 77% leaf in winter. *Pseudomys gracilicaudatus* shows little change in seed consumption from summer (34%) to winter (31%), but this holds true for all diet items so that this species shows the least seasonal change. All the other species increase the amount of leaf or stem in the diet in winter but *P. oralis* shows by far the greatest change from 45% in summer to 77% in winter.

Pseudomys pilligaensis appears to be closest in diet to *P. novaehollandiae* with its dependence on seed (95%) in summer to 62% in winter. The magnitude of shift in the diet is the lowest for the genus. *Pseudomys pilligaensis* had the highest percentage of seed (62%) in its winter diet , which is followed closest by *P. novaehollandiae* with 45% and *P. apodemoides* with 55%. These observations may be a reflection of differences in the availability of seed in the habitats of these species, as *P. pilligaensis* occupies heath and open forest, as does *P. novaehollandiae,* while *P. oralis* occupies forest, *P. fumeus* subalpine heathland and woodland, with *P. apodemoides* found only in mature heath.

CONCLUSIONS

Pseudomys pilligaensis appears to be similar to other *Pseudomys* studied (Cockburn, 1980, 1981a, 1981b; Thompson 1980; Luo and Fox 1994 and Fox ,Read, Jefferys and Luo,1994) which broaden their diet in winter to incorporate a greater range of seed types and a higher proportion of other plant material (e.g. an increase in stem, leaf or sporangia). It is not clear whether this reflects an active choice by *P. pilligaensis* to select for increased amounts of leaf and a wider range of seed types or a default selection caused by lack of alternative dietary items in such a restricted habitat. These results indicate that *P. pilligaensis* is a granivore, as the diet is dominated by seed (over 50%) both in spring/summer and winter. This is consistent with Kerley and Whitford's (1994) definition "The term granivore,... ... should refer to animals whose diet is dominated (>50%) by[seed]." However *P. pilligaensis* could be operating in a general opportunistic manner (i.e. interpreting opportunistic species as one that is utilizing an unpredictable environment, differently over the seasons and years) considering the very restricted habitat that the species survives in today.

These results are important as they provide the only information to date on the diet of *P. pilligaensis* in the wild. As the species is classed as rare, limited and vulnerable (Strahan 1995) this information may contribute to better understanding of its habitat requirements and conservation management.

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